भारतीय मानक

IS 18462 : 2023

Indian Standard

इलेक्ट्रॉनिक अधिस्फोटकों — विशिष्टि

Electronic Detonators — Specification

ICS 71.100.30

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Explosives and Pyrotechnics Sectional Committee, CHD 26

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Explosives and Pyrotechnics Sectional Committee had been approved by the Chemical Division Council.

A detonator is a device used to trigger an explosive. Detonators are usually initiated by mechanical or electrical means or by means of shock.

Electronic detonators are modern and fully programmable detonators capable of two way communication. Each detonator contains a circuit board that can be programmed to initiate at precise millisecond timing within a firing sequence. Detonators are usually individually programmed via the use of a hand held logger or programmer and initiated via a firing unit.

Electronic detonator systems can be fitted in two categories, *Pre-programmed electronic detonators* (or fixed delay detonators) for which the delay time is programmed at the factory before dispatch and the user cannot change the delay. These detonators are normally numbered in such a way that the user recognizes its intended delay time, and *Programmable delay detonators* for which the delay time of these detonators is programmed prior to blasting, by either the logger or programmer or the firing unit.

Detonators are usually initiated by electrical methods. As per the requirements, they may also be initiated by mechanical or shock. However, in case of electronic detonators, they are initiated by means of electronic signature/signal, which is the safest and highly secured technique. In the interest of safety and to avoid unintended operation it is desired that the electronic detonators are controlled by a person authorized to use them. Hence, there is generally a security access control to the equipment like logger, blaster and in addition a geo-fencing can also be added for enhanced safety.

In the formulation of this standard, assistance has been derived from the EN 13763 series ‘Explosives for civil uses — Detonators and relays’.

There is no ISO specification for the product.

The composition of the Committee responsible for the formulation of this standard is given in Annex R.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 2022 ‘Rules for rounding off numerical values (*second revision*)’. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

ELECTRONIC DETONATORS — SPECIFICATION

1 SCOPE

1.1 This standard prescribes the requirements, methods of sampling, and tests for electronic detonators used for blasting purposes.

1.2 This standard is not applicable on electronic detonators specifically meant for defense applications.

2 REFERENCES

The standards given below contain provisions which through reference in this text, constitute provisions of and necessary adjuncts to this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of these standards:

IS No.	*Title*
IS 1260 (Part 1) : 1973	Pictorial marking for handling and labelling of goods: Part 1 Dangerous goods (*first revision*)
IS 4905 : 2015/ ISO 24153 : 2009	Random sampling and randomization procedures (*first revision*)
IS 6609 (Part 3) : 2023	Commercial blasting explosives and accessories — Methods of test: Part 3 Detonators, general and permitted (*first revision*)
IS 10081 : 1981	Glossary of terms relating to commercial explosives, pyrotechnics and blasting practices
IS 14700	Electromagnetic compatibility (EMC):
(Part 4)	Testing and measurement techniques,
(Sec 3) : 2023/ IEC 61000-4-3 : 2020	Radiated, radio-frequency, electromagnetic field immunity test (*second revision*)
(Sec 4) : 2018/ IEC 61000-4-4 : 2012	Electrical fast transient/burst immunity test (*second revision*)
(Sec 6) : 2016/ IEC 61000-4-6 : 2013	Immunity to conducted disturbances, induced by radio — frequency fields

3 TERMINOLOGY

For the purpose of this standard, the terms and definitions given in IS 10081, in addition to the following, shall apply:

3.1 Delay Number — Number given to a delay detonator to show its relative position in a given series.

3.2 Delay Time — Elapsed time between the activation and detonation of an electronic delay detonator.

3.3 Electronic Detonator — Detonator assembly capable of two way communication in which the time delay is achieved by means of an electronic chip activated by electronic signature signal/stimuli.

3.4 Electronic Detonators Firing Unit/Electronic Exploder — Instrument used to initiate an electronic detonator.

NOTE — Under the *Coal Mines Regulation*, 2017, the electronic detonator firing unit/electronic exploder used in any underground coal mine shall be intrinsically safe and have been approved by the Director General of Mines Safety.

3.5 Flash-Over Voltage — Minimum direct voltage which will give electrical breakdown between the conductor system and metal casing of the detonator.

3.6 Nominal Delay Interval — Difference in nominal delay time between adjacent delay numbers in a series of delay detonators.

3.7 Permitted Electronic Detonators — Under the *Coal Mines Regulation*, 2017, only detonators which have been approved by the Director General of Mines Safety are used in any below ground coal mine in which approved safety lamps are required to be used. Such electronic detonators are termed as permitted electronic detonators and these include electronic detonators for simultaneous firing, and also delay detonators.

4 GRADES

The detonators shall be of two grades, namely:

a) *Grade* A — General; and
b) *Grade* B — Permitted.

5 REQUIREMENTS

Unless and otherwise specified, the following requirements shall be applicable to both grades of the electronic detonators:

5.1 Drop Test

When subjected to drop test as prescribed in **4.2** of IS 6609 (Part 3), none of the detonators shall detonate on impact and after the test, each tested sample shall be checked again for its firing characteristic. All detonators shall be functional after the drop test.

NOTE — While performing the test as per **4.2** of IS 6609 (Part 3), in case of electronic detonators, cut the leading wire so that up to 10 cm length left instead of 20 cm wire as prescribed in clause **4.2.1** of IS 6609 (Part 3).

5.2 Snatch Test

When subjected to the snatch test as prescribed in **4.3** of IS 6609 (Part 3), the detonators shall not fire when a jerk is applied to the lead wires.

5.3 Vibration Test

When subjected to vibration test as laid down in **4.4** of IS 6609 (Part 3), the detonators shall not explode during the test.

5.4 Strength of Detonators

5.4.1 *By Sand Bomb Method*

When the detonators are tested in sand bomb as prescribed in **4.5** of IS 6609 (Part 3), the percentage of crushed sand passing through 500 micron and 250 micron IS Sieves shall be as follows:

Sl No.	*Strength of Detonator*	*Percentage of Sand Passing Through*	
		500 micron IS Sieve	250 micron IS Sieve
(1)	(2)	(3)	(4)
i)	No. 6	≥ 35	≥ 30
ii)	No. 8	≥ 50	≥ 45

5.4.2 *By Lead Plate Method*

When the detonators are subjected to the test as prescribed in **4.6** of IS 6609 (Part 3), the general electronic detonators shall produce dent on the lead plate corresponding to at least C-3 class [**4.6.3.3** of IS 6609 (Part 3)] while permitted electronic detonators shall produce dent on the lead plate corresponding to at least B–3 class [**4.6.3.3** of IS 6609 (Part 3)].

5.5 Water Resistance

When the detonators are subjected to water resistance test as prescribed in **4.1** of IS 6609 (Part 3), the detonators shall satisfy the following requirements;

a) After being subjected to the test, all the tested samples shall fire; and

b) On firing, the detonators shall pass the requirements of **5.4.2**.

5.6 Delay Time Measurement

5.6.1 The delay time at ambient temperature when measured for the permitted electronic detonator as per the Annex B shall be within ± 2 milliseconds of the given delay time.

5.6.2 The delay time at ambient temperature when measured for the general electronic detonator as per the Annex B shall be as follows:

a) For electronic detonators having delay time between 0 milliseconds to 1 000 milliseconds, the measured delay time shall be within ± 2 milliseconds of the given delay time; and
b) For electronic detonators having delay time greater than 1 000 milliseconds, the measured delay time shall be within ± 0.2 percent of the given delay time.

NOTE — In view of varying applications of general electronic detonators, the user may prescribe tighter tolerances depending on their application.

5.7 Overvoltage Immunity Test

When the detonators are subjected to overvoltage immunity test as prescribed in Annex A, the detonators shall satisfy the following requirements:

a) None of the detonators shall detonate during the test; and

b) As per the manufacturers' specification, the logger or the blaster shall be capable of identifying the detonators for which the electronic module has been damaged during the test and the same shall be discarded.

NOTE — In case of electronic module damage, the detonator will not respond to the logger/blaster, thereby making the logger/blaster to identify such non–functional detonators, such detonators shall be considered as damaged and shall be discarded. All the test samples subjected to 240 V (rms) shall be discarded after the test.

6 TYPE TESTS

6.1 Gas Incendivity Test (Only for Grade B)

When Grade B electronic detonators are subjected to gas incendivity test as prescribed in **5.2** of IS 6609 (Part 3), they shall not cause more than 14 gas ignitions in 200 tests.

NOTES

1 Gas incendivity test is a type test and it is not required to be carried out on every lot if the particular type of construction has been tested by CSIR – Central Institute of Mining and Fuel Research and approved by Directorate General of Mines Safety.

2 This test is required for electronic detonators intended for use in underground coal mines.

6.2 Coal Dust Incendivity Test (Only for Grade B)

When Grade B electronic detonators are subjected to coal dust incendivity test as prescribed in **5.3** of IS 6609 (Part 3), they shall not cause any ignition in 50 tests.

NOTES

1 Coal dust incendivity test is a type test and it is not required to be carried out on every lot if the particular type of construction has been tested by CSIR – Central Institute of Mining and Fuel Research and approved by Directorate General of Mines Safety.

2 This test is required for electronic detonators intended for use in underground coal mines.

6.3 The following tests are type tests which are to be carried out at the manufacturing facility at the start of initial production as well as when there is a change in design of the detonator. All the type tests shall be shall be performed in presence of PESO, except gas incendivity and coal dust incendivity tests which are to be performed at CSIR – CIMFR and approved by DGMS.

6.3.1 Delay Time Performance at Extreme Temperature Conditions

6.3.1.1 The delay time at extreme temperatures specified by the manufacturer when measured for the permitted electronic detonator as per the Annex B shall be within ± 2 milliseconds of the given delay time.

6.3.1.2 The delay time at extreme temperatures specified by the manufacturer when measured for the general electronic detonator as per the Annex B shall be as follows:

a) For electronic detonators having delay time between 0 milliseconds to 1 000 milliseconds, the measured delay time shall be within ± 2 milliseconds of the given delay time; and

b) For electronic detonators having delay time greater than 1 000 milliseconds, the measured delay time shall be within ± 0.2 percent of the given delay time.

NOTE — In view of varying applications of general electronic detonators, the user may prescribe tighter tolerances depending on their application.

6.3.2 Thermal Stability Test

When the detonators are subjected to thermal stability test as prescribed in Annex C, there shall be no detonation.

6.3.3 Impact Test (Applicable Only for Detonators Having Copper and Steel Shells)

When tested as per the method prescribed in Annex D, the mean height and the minimum height at which explosion is observed shall be greater than 0.4 m and 0.2 m respectively.

6.3.4 Resistance of Lead Wires to Abrasion

When tested as per the method prescribed in Annex E, the mean and minimum values of testing time at the point of failure shall be larger than the values listed in Table 1. The manufacturer shall provide a COA.

Table 1 Resistance to Abrasion

(*Clause* 6.3.4)

Sl No. (1)	**Category** (2)	**Test Loading,** N (3)	**Mean Value,** s (4)	**Minimum Value,** s (5)
i)	1	4.0	6.0	5.1
ii)	2	12.2	4.5	3.8

6.3.5 Resistance of Lead Wires to Cutting Damage

When tested as per the method prescribed in Annex F, there shall not be any electrical contact between the lead wire conductor and the tungsten carbide cutting edge. The manufacturer shall provide a COA.

6.3.6 Resistance of Lead–Wires to Cracking in Low–Temperature Conditions

When tested as per the method prescribed in Annex G, there shall not be any through cracking of the insulation. The manufacturer shall provide a COA.

6.3.7 Mechanical Strength of Lead–Wires, Connections, Crimps and Closures

When tested as per the method prescribed in Annex H,

a) During the sudden and slow release, no detonator shall detonate;

b) During the sudden release test, no leading wire shall break and the plug shall not be pulled out of the shell;

c) During the slow release test, no plug shall pull out of the shell; and

d) In the functioning test, all the detonators shall detonate.

6.3.8 Resistance of Detonators to Bending

When tested as per the method prescribed in Annex J, none of the detonators shall initiate. Also, there shall be no cracks or breaks in any of the shells.

6.3.9 Resistance of Detonators to Electrostatic Discharge

When and electronic detonator is tested as per the method prescribed in Annex K, there shall be no unintended initiation.

6.3.10 Determination of Flash–Over Voltage of Electronic Detonators

When tested as per the method prescribed Annex L, no test specimen shall be initiated. The upper value of the flashover voltage shall be less than 6 000 V.

6.3.11 Determination of Capacitance, Insulation Resistance, and Insulation Breakdown of Lead–Wires

When tested as per the method prescribed in Annex M, the test specimen shall satisfy the following requirements:

a) $C_m + 2.33\sigma \leq 500\ pF$,

where

C_m = mean of the capacitance of test specimen; and

σ = standard deviation.

b) Lowest value of the insulation resistance shall not be less than 50 MΩ, and

c) No breakdown of insulation shall occur when a voltage of 5 000 V is applied.

6.3.12 System Function Test

The purpose of this test is to determine the proper operation and ignition of the detonators connected to the firing device with the specified wire length of the firing line as defined by manufacturer. When tested in accordance with the procedure mentioned in Annex N all detonators shall fire.

6.3.13 Electromagnetic Compatibility and Interference Test

The purpose of this test is to verify that electronic initiation systems are safe and reliable when subjected to electromagnetic radiation. When tested in accordance with the procedure mentioned in Annex P:

a) No dummy detonator shall be initiated;

b) No dummy detonator shall be initiated until the firing command is ordered. After giving the firing command all dummy detonators shall be initiated; and

c) A temporary loss of function in equipment is allowed, providing the loss is self-recoverable, or can be restored by operation of the controls of the equipment.

6.3.14 Abort Function Test

Every electronic initiation system must have a built-in safe abort mechanism. When tested in accordance with the procedure mentioned in Annex Q none of the test samples shall initiate.

7 PACKING AND MARKING

7.1 Packing

The detonators shall be packed as agreed to between the purchaser and the supplier. The packing shall conform to the provisions of *Explosives Rules*, 2008.

7.2 Marking

The marking shall further be in conformity to the provisions of *Explosives Rules*, 2008.

7.3 BIS Certification Marking

The product(s) conforming to the requirements of this standard may be certified as per the conformity assessment schemes under the provisions of the *Bureau of Indian Standards Act*, 2016 and the Rules and Regulations framed thereunder, and the products may be marked with the Standard Mark.

8 SAMPLING

8.1 Lot

8.1.1 Cases of detonators of same grade, same type and belonging to the same batch of manufacture shall be grouped together to constitute a lot.

8.1.2 Detonators constituting the sample shall be drawn from each lot separately for deciding the conformity of the lot to the requirements of the specification.

8.2 Scale of Sampling

Number of detonators to be selected at random from the lot shall depend on the lot size and shall be in accordance with co1 (3) of Table 2. In order to ensure randomness of selection, procedures given in IS 4905 may be followed.

Table 2 Scale of Sampling of Electronic Detonators

(*Clause* 8.2)

Sl No. (1)	No. of Detonators in the lot (2)	Sample size (3)
i)	Up to 10 000	100
ii)	10 001 to 25 000	200
iii)	25 001 and above	250

8.3 Number of Tests — The number of detonators taken for the determination of each characteristic shall be as given below in Table 3:

Table 3 No. of Detonators for Each Test

(*Clause* 8.3)

Sl No. (1)	Test/Characteristic (2)	No. of Detonators to be Tested (3)
i)	Water resistance	5
ii)	Drop test	5
iii)	Snatch test	5
iv)	Vibration test	20
v)	Strength test	5
vi)	Overvoltage immunity test	5
vii)	Delay timing test	20

8.4 Criteria for Conformity

For deciding the conformity of the lot to the requirements of this specification, the test results of each characteristic shall meet the corresponding requirements specified in the relevant clauses.

ANNEX A

OVERVOLTAGE IMMUNITY TEST

(*Clause* 5.7)

A-1 INTRODUCTION

This test specifies a method of testing the immunity of electronic detonators with wire leads when subjected to overvoltage.

A-2 PRINCIPLE

Electronic detonators are subjected to the test voltage across the two lead wires and between the lead wires shorted and the electronic detonator shell, if the shell is made of conductive material. In the case of direct current, tests shall be done in both polarities. The duration of each test is not less than 10 s (or for a longer period as stipulated by the manufacturer).

A-3 APPARATUS AND TEST LEVELS

A schematic representation of the test apparatus is given in Fig. 1. The overvoltage test levels aregiven in Table 4.

Table 4 Overvoltage Test Levels

(*Clause* A–3)

Sl No.	**Test Level No.**	**1**	**2**	**3**
(1)	(2)	(3)	(4)	(5)
i)	Simulates exposure to	Vehicular battery (D.C.)	Telephone loop (D.C.)	Mains Power (A.C.)
ii)	Voltage (V)	24	48	240 rms
iii)	Current capability of the source (A), *Min*	1	0.25	1
iv)	Tolerance on voltage	± 5%	± 5%	± 5%
v)	Test duration, s	10	10	10

NOTE — The actual current passing through the detonator will be much lower than the current capability of the source.

A-4 TEST SAMPLES

Take 5 electronic detonators of the same type and from the same manufacturer for each stress test level and for each combination of wiring. Any product variant with differing manufacturing configuration or specification (or both), shall also be tested. The lead wire length shall not exceed 3.5 m. Stabilize all devices for test at an ambient temperature of between 15 °C and 28 °C for at least 1 h before testing.

NOTE — Ensure that the particular recommendations of the manufacturer on lead wire configurationand handling, if any, are followed.

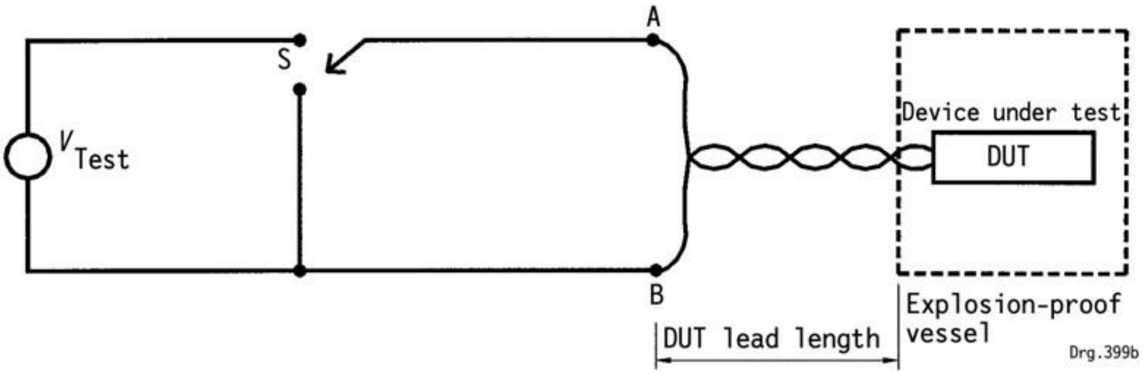
A-5 PROCEDURE

A-5.1 Subject the electronic detonator sequentially to voltage stress (in both polarities in the case of d.c. voltages) across all combinations of pairs of lead wires of the electronic detonator under test. The duration of eachstress period is a minimum of 10 s, or longer, as recommended by the manufacturer.

A-5.2 Only repeat the test sequentially between each single lead wire and the electronic detonator shell if thelatter is of conductive material.

A-5.3 In the event of an ignition, stop the test and record the electronic detonator as having failed the test.

A-5.4 Repeat the test on each detonator.



The DUT lead length shall not exceed 3.5 m.

Legend:

A and B Terminals on the test apparatus where the wires to the DUT are connected.

S Switch or relay operated from a point of safety.

FIG. 1 SCHEMATIC REPRESENTATION OF THE TEST APPARATUS FOR THE OVERVOLTAGE IMMUNITY TEST

ANNEX B

TEST METHOD FOR THE DETERMINATION OF DELAY ACCURACY OF ELECTRONIC DETONATORS

(*Clauses* 5.6, 6.3.1)

B-1 GENERAL

The purpose of this method is to determine the delay accuracy of an electronic detonator.

B-2 TEST PIECES

B-2.1 For Test at Ambient Temperature (*see* 5.6)

B-2.1.1 The test can be performed on live detonators or dummy detonators.

B-2.1.2 For permitted electronic detonators, test 20 detonators of each delay number specified by the manufacturer.

B-2.1.3 For programmable electronic detonators, test 20 detonators evenly distributed at approximately 10 percent, 25 percent, 5 percent, 75 percent and 100 percent of the time scale specified by the manufacturer.

B-2.1.4 For pre-programmed electronic detonators, preprogram and test 20 detonators evenly distributed at approximately 10 percent, 25 percent, 50 percent, 75 percent and 100 percent of the time scale specified by the manufacturer.

B-2.2 For Test at Extreme Temperatures (*see* 6.3.1)

For all types of electronic detonators test at the minimum and at the maximum temperature, specified by the manufacturer, 20 detonators or dummy detonators at the longest delay time specified by the manufacturer.

B-3 APPARATUS

B-3.1 Firing unit and/or programming unit and/or testing unit specified by the manufacturer shall only be used to make the tests.

B-3.2 Timer or oscilloscope with the means to measure delay time between the start pulse and the stop pulse with an accuracy of ± 10 micro seconds.

B-3.3 Mean to provide the start pulse, can be either the signal given by the firing unit or a detonator with a zero delay (according to manufacturer specification).

B-3.4 Means for providing a stop pulse to the timer/oscilloscope consisting of:

a) For the tests with the complete detonator: an optical sensor or pressure sensor or ionization sensor or electrical continuity sensor providing an electric pulse when the base charge of the detonator is initiated; and
b) For tests with the dummy detonator: a sensor, according to the device used to replace the fuse-head, providing an electric pulse when such device simulate the initiation.

B-4 PROCEDURE

B-4.1 Conditioning

Condition the detonators/dummy detonators for at least 2 h before testing at a temperature specified by the manufacturer. For programmable and pre-programmed electronic detonators, program the detonators/dummy detonator before conditioning. Before conditioning, detonators/dummy detonators shall be checked with the appropriate means according to manufacturer procedure.

B-4.2 Testing

Connect the detonator/dummy detonator to the firing unit, install the appropriate start pulse sensor/or the zero detonator and the appropriate stop pulse sensor, initiate (according to manufacturer procedure) the detonator/dummy detonator and record each individual delay time.

NOTE — Firing tests at high and low temperature are made, if possible, in the conditioning device.

B-5 TEST REPORT

It shall clearly indicate the following results:

a) The delay time measured for various samples.

ANNEX C

THERMAL STABILITY TEST

(*Clause* 6.3.2)

C-1 OUTLINE

The method describes the determination of the thermal stability of electronic detonators by providing the heat treatment to the test pieces.

C-2 APPARATUS

Oven/heating cabinet which is capable of maintaining a prescribed temperature within ± 2 °C.

NOTE — The apparatus should be of such a design that it can ensure the prevention of sympathetic detonation.

C-3 TEST PIECES

For a specific type, having a similar design and composition of fuse head, primary charge of which has a similar chemical composition and secondary charge has a similar chemical composition, select about 25 detonators. In case part of series is formed by the detonators with the difference in delay times, selection of 25 detonators is made with the evenly distributed delay times throughout the series as possible.

C-4 PROCEDURE

In the heating cabinet, store the test pieces for 48 h at a temperature of (75 ± 2) °C. 12 of the test pieces are to be placed in a rack while keeping the base upwards and other 13 of the test pieces are to be placed in a rack while keeping their base downwards. Record any kind of incident of detonation.

C-5 TEST REPORT

It shall clearly indicate the following information:

a) The result of the test stated as detonation or no detonation; and
b) The relevant test parameters (the temperature and time).

ANNEX D

IMPACT TEST

(*Clause* 6.3.3)

D-1 GENERAL

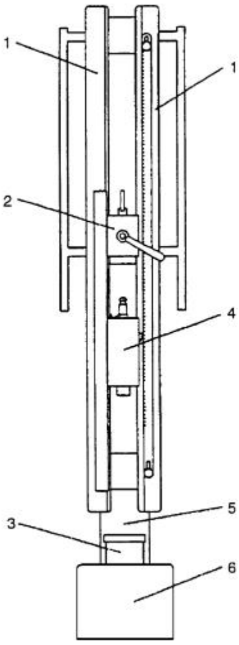
The resistance of a detonator to initiation or damage by impact gives an indication of its safety in handling, transportation and use.

D-2 APPARATUS

The apparatus consists of a drop hammer (for example, BAM fall hammer), comprising of a main anvil and an intermediate anvil, a guide piece, a column, a cast steel block with base, a locating plate, a percussion cylinder, a striking head, guides and a drop weight with a release mechanism (*see* Fig. 3 and Fig. 4).

D-2.1 Drop Hammer

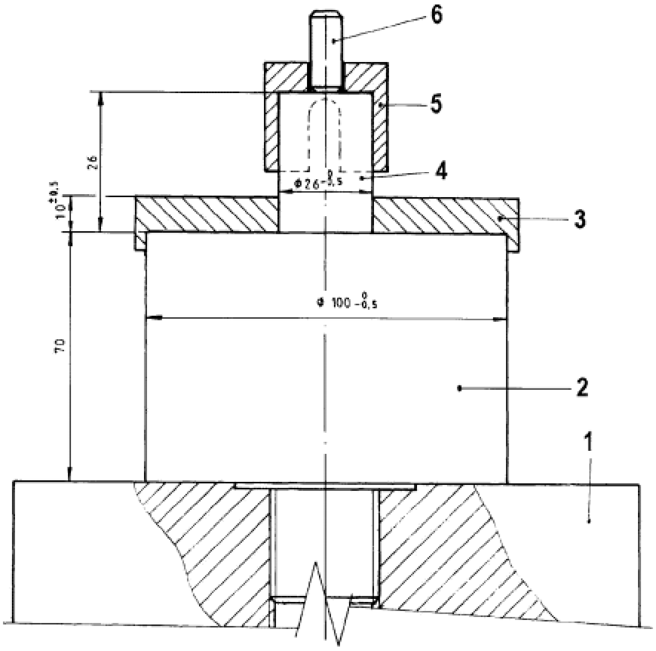
D-2.1.1 An anvil made of steel is screwed onto the block of steel and a cast base. The steel that is used for the main anvil and the intermediate anvil is of the similar type as for the striking head of the drop weight. The percussion cylinder is actually a roller bearing having rounded edges and polished surfaces and is made up of steel. The support that has a column fixed on it (which is made from a seamless drawn steel tube) is bolted to the backside of the steel block.



Key

1	Guides
2	Release devices
3	Anvil
4	Drop weight
5	Column
6	Steel weight

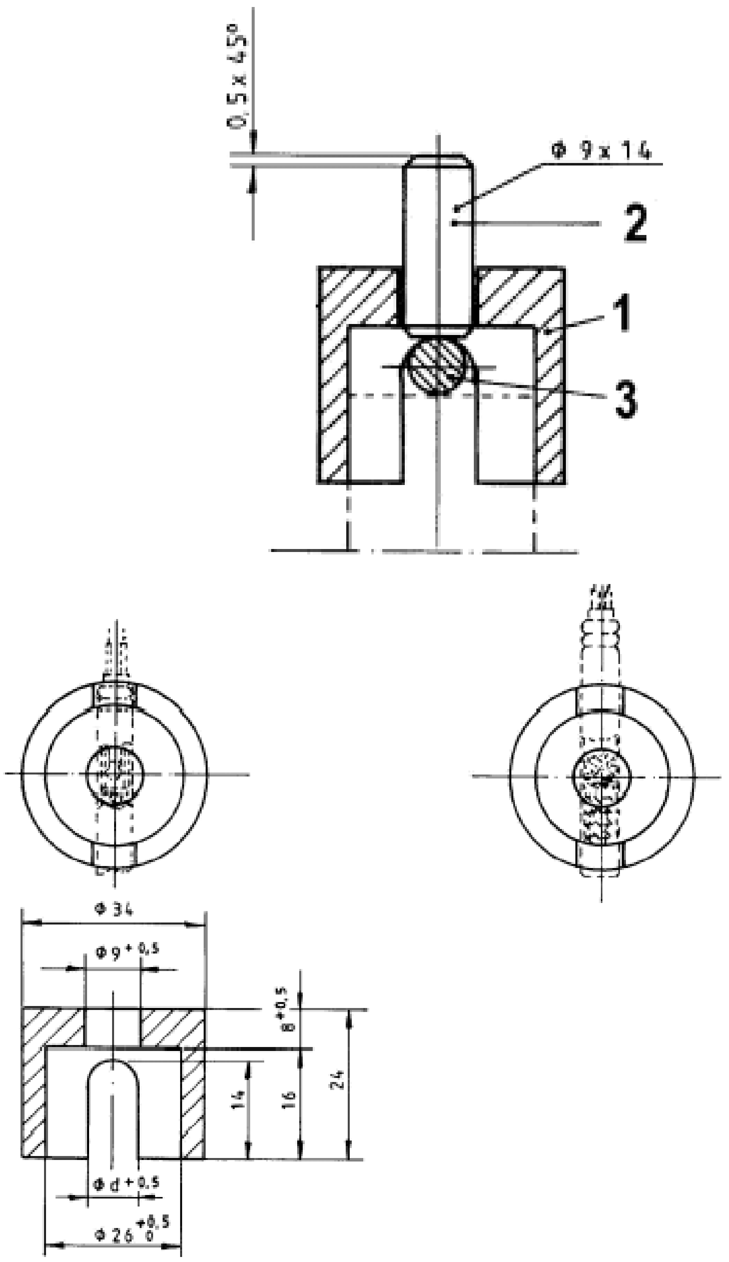
FIG. 2 ARRANGEMENT OF THE BAM FALL HAMMER (COLUMN, STEEL BLOCK AND THE ANVIL)



Key

1	Steel block
2	Anvil
3	Locating plate
4	Intermediate anvil
5	Guide piece
6	Percussion cylinder

FIG. 3 BOTTOM PART OF THE BAM FALL HAMMER



Key

1 Guide piece
2 Percussion cylinder
3 Detonator
d Outer diameter of detonator

FIG. 4 DIMENSIONS OF THE PERCUSSION CYLINDER AND THE GUIDE PIECE

D-2.1.2 The two guides that are fixed to the column with the help of three cross pieces are attached to a toothed rack, in order to limit the rebound of drop weight, and a graduated scale of moveable nature just to adjust the drop height. The guides should be vertical.

D-2.1.3 In between the guides, the drop weight release mechanism is adjustable and is clamped to them by means of lever mechanism.

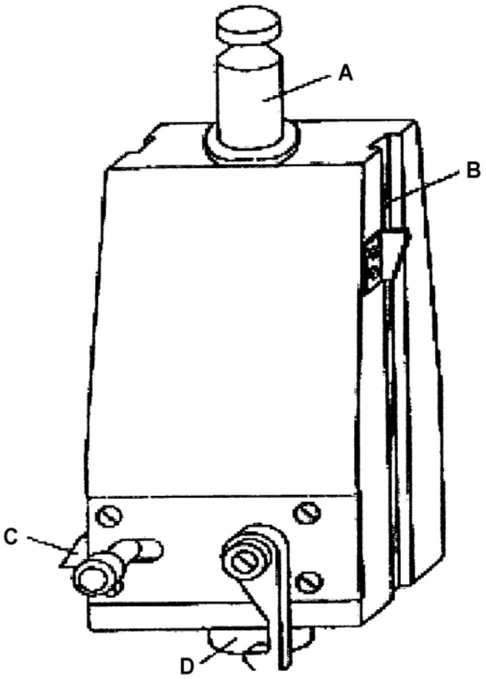
D-2.1.4 The apparatus should be firmly secured to block of concrete of minimum dimensions of (0.6 × 0.6 × 0.6) m with the help of four anchoring bolts.

D-2.2 Drop Weight

D-2.2.1 Mass of drop weight is (2 000 ± 2) g and has two locating grooves to hold it between the guides when it drops. A rebound catch, a removable cylindrical striking head and a suspension spigot are screwed onto the drop weight. Fig. 5 illustrates the design of the drop weight of BAM fall hammer.

D-2.2.2 The removable striking head, is made of hardened with a diameter of 25 mm and with a polished surface.

D-2.2.3 The release mechanism should be controlled remotely.



Key

A Suspension spigot

B Locating groove

C Rebound catch

D Striking head

FIG. 5 DROP WEIGHT OF BAM FALL HAMMER

D-3 TEST PIECES

Select about 50 detonators of a particular type, fuse heads and ignition systems of which have same construction and composition of relevant parts around the fuse head or other bridgewire ignition system and whose primary charges (or the element that can perform the similar function as a primary charge) have the same composition and design. In case the detonators forms a part of series with different delay times, select 50 detonators with delay times distributed as evenly as possible throughout the series.

D-4 PROCEDURE

D-4.1 Impact on the Fuse Head or Other Ignition System

Test 25 detonators in this position. Mark the location of the fuse head or other ignition system on the outside of the detonator and place the detonator in the impact testing apparatus (Fig. 2), so that the fuse head or other ignition system is positioned between the percussion cylinder and the intermediate anvil. Drop the hammer from the specified height (with a tolerance of ± 5 mm) and observe whether the detonator explodes. The mean height is calculated using the Bruceton method as given in **D–4.3** which is based on determining the level of stimulus at which there is a 50 percent probability of obtaining a positive result.

D-4.2 Impact on the Primary Charge

Test 25 detonators in this position. Mark the location of the primary charge on the outside of the detonator and place the detonator in the impact testing apparatus (Fig. 2), so that the primary charge is positioned between the percussion cylinder and the intermediate anvil. Drop the hammer from the specified height (with a tolerance of ± 5 mm) and observe whether the detonator explodes. The mean height is calculated using the Bruceton method as given in **D-4.3** which is based on determining the level of stimulus at which there is a 50 percent probability of obtaining a positive result.

If the detonator does not have a primary charge, arrange the detonator so that the impact occurs on the element which performs the same function as a primary charge, that is, initiation of the base charge.

D-4.3 the Bruceton method involves the application of different levels of stimulus and determining whether or not a positive reaction occurs. The performance of the trials is concentrated around the critical region. It takes place by decreasing the stimulus in one level at the next trial if a positive result is obtained and by increasing the stimulus in one level if a negative result is obtained. Usually about five preliminary trials are performed to find a starting level in approximately the right region and then at least 25 trials are performed to provide the data for the calculations.

NOTE — If no explosion occurs at the maximum height of the apparatus (2 m), test the next piece at the same height. Continue the procedure until all test pieces have been tested.

D-5 CALCULATION

In determining the level at which the probability of obtaining a positive result is 50 percent (H_{50}), only the positive results (+) or only the negative results (–) are used, depending on which has the smaller amount. If the numbers are equal, either may be used. The data are recorded in a table (for example, as in Table 5) and summarized as shown in Table 6. Col (1) of Table 6 contains the drop heights, in ascending order, starting with the lowest level for which a test result is recorded. In col (2), '*i*' is a number corresponding to the number of equal increments above the base or zero line. Col (3) contains the number of positive results [$n(–)$] for each drop height. The fourth column tabulates the result of multiplying '*i*' times '*n*' and the fifth column tabulates the results of multiplying the square of '*i*' times '*n*'. A mean is calculated from the following equation:

$$H_{50} = c + d \times [(A/N_S) \pm 0.5] \qquad \ldots\ldots(1)$$

where

$N_s = \Sigma\, n_i$;

$A = \Sigma\, (i \times n_i)$;

c is the lowest drop height; and

d is the height interval.

If negative results are used, the sign inside the brackets is positive; it is negative if positive results are used. The standard deviation, *s*, may be estimated using:

$$s = 1.62 \times d \times [(N_S \times B — A^2)/N_S^2) + 0.029] \ldots\ldots.(2)$$

where

$B = \Sigma\, (I^2 \times n_i)$.

Example:

Using the following data from Tables 5 and 6: lowest drop height 10 cm; height interval 5 cm; sum of $i.n$ (–) 16; sum of $i^2.n$ (–) 12,

The mean height is given by equation (1) as:

$$H_{50} = 10 + 5 \times [(16/12) + 0.5] = 19.2 \text{ cm}$$

And the standard deviation by equation (2) as:

$$s = [(12 \times 30 — 162)/122) + 0.029] = 6.1$$

The minimum height at which explosion occurred = 15 cm.

Table 5 Recording Data

(*Clause* D–5)

Drop Height (cm)																											
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	+	–
30								+																		1	
25							–		+				+				+		+							4	1
20				+		–				+		–		+		–		–		+		+				5	4
15	+		–		–						–				–						–		+		+	3	5
10		–																						–			2
																										13	12

Table 6 Summarizing Data

(*Clause* D–5)

Height (cm)	Calculations Using Negatives			
	$i(-)$	$n(-)$	$i(-).n(-)$	$i^2(-).n(-)$
25	3	1	3	9
20	2	4	8	16
15	1	5	5	5
10	0	2	0	0
Total		$N_s = 12$	$A = 16$	$B = 30$

D-6 TEST REPORT

It shall clearly indicate the following information:

a) The mean height and standard deviation as calculated from the above procedure; and

b) The minimum height at which the explosion occurred in at least 1 out of 25 trials.

ANNEX E

RESISTANCE OF LEADING WIRES TO ABRASION

(*Clause* 6.3.4)

E-1 GENERAL

During usage on site, the insulation on the leading wires of electronic detonators can be subjected to many forces, including abrasive forces when drawn over rough surfaces and/or cutting forces when drawn over a sharp edge. The plastics material is worn away gradually by abrasion. This method determines the ability of leading wire insulation to resist the abrasive forces likely to be experienced in normal use.

E-2 PRINCIPLE

The piece taken for test is subjected to abrasion by an abrasive surface, moving on a particular speed, while applying a particular load. For leading wires the time taken for the insulation to be penetrated is determined.

E-3 APPRATUS

E-3.1 It comprises of pivot (1), hinged arm (2), leading wire (3), weight (4), pulley (5), rod (6), weight (7), clamp screw (8) for attaching the test piece, clamp for attaching the test piece (9), rotor (10) *see* Fig. 6.

E-3.2 Steel or Brass Rotor — Having a perimeter of (432 ± 2) mm to which 3 abrasive are attached with the help of double sided adhesive tape or glue. It is to be ensured that the electrical contact between the rotor and the abrasive strips is made for example, at the slits on the rotor, the point where the ends of the abrasive strips are inserted (as given in Fig. 6). The rotating speed of the rotor shall be around (9.96 ± 0.18) rpm, with a mean peripheral speed of (0.075 ± 0.001) m/s.

NOTE — Depending upon the principle of attachment (for example, tape or glue) of the abrasive strip to the rotor, the abrasive strip have to be carefully bent by making a use of a suitable tool so as to fit properly against the rotor surface.

E-3.3 Motor — able to maintain a constant speed of rotation whatever load is applied to the rotor (*see* Fig. 7).

E-3.4 Load — It is applied to the test piece with the help of hinged arm.

E-3.5 Hinged Arm — It should be made of brass or steel as given in Fig. 8. At the start point, the hinged arm shall apply a load of (8.35 ± 0.05) N to the test piece.

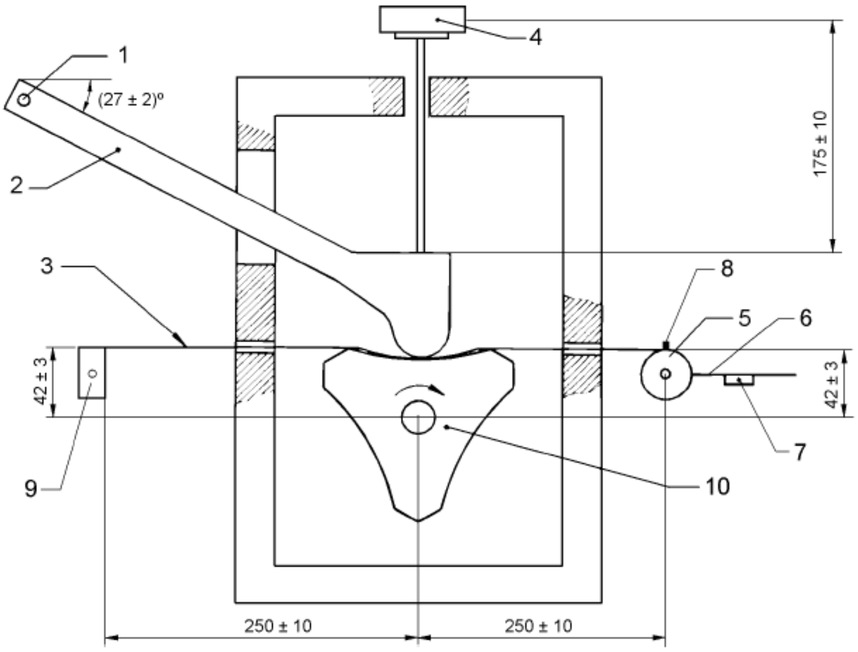
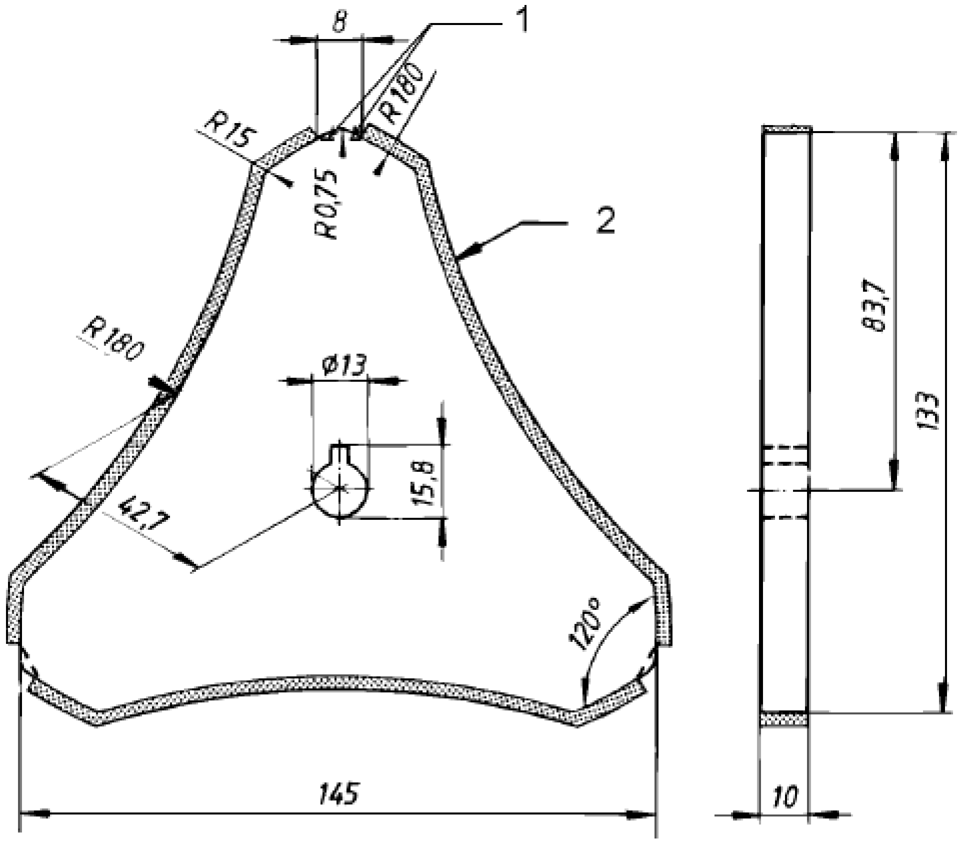


FIG. 6 ABRASION TEST APPARATUS WITH ROTOR IN THE STARTING POSITION



Key

1 Slit for the end of the abrasive strip
2 Abrasive strip

FIG. 7 ROTOR

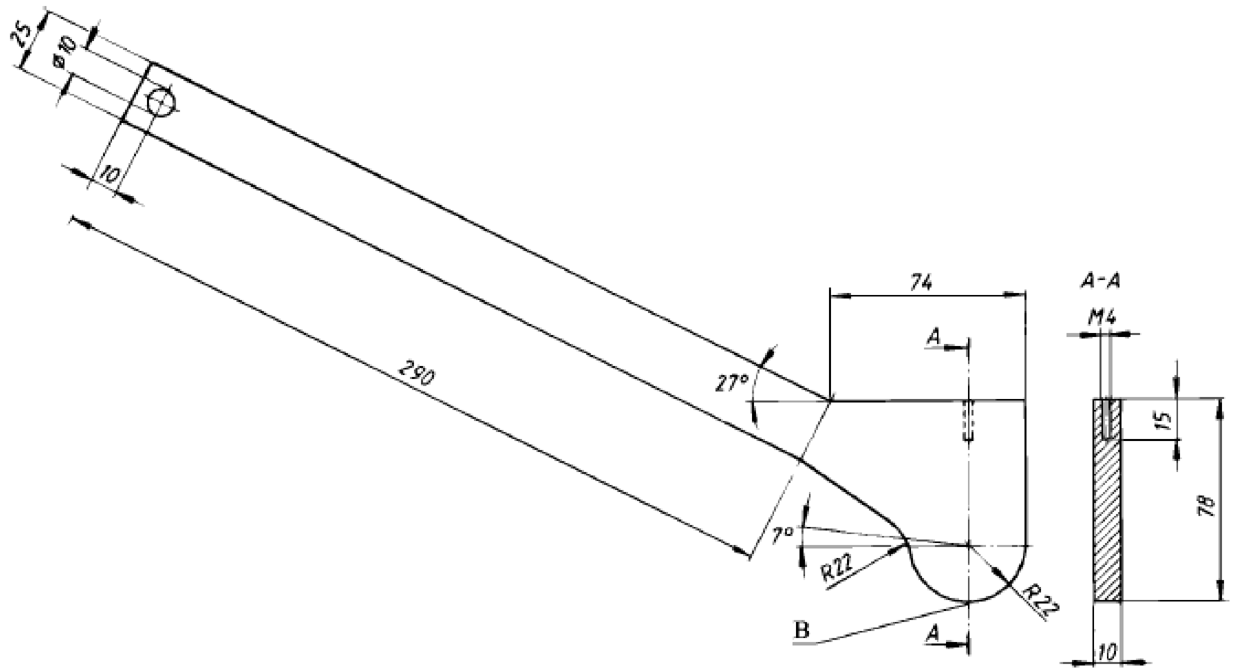


FIG. 8 HINGED ARM

E-3.6 Abrasive Strips — 3 pieces with the approximate dimensions of 10 mm × 145 mm each, made from grinding steel.

E-3.7 Pulley — with a diameter of (70 ± 1) mm, sufficient for the application of a tensile load of (8.1 ± 0.5) N to the test piece, with a rod and a weight.

NOTES

1 A DC motor having an output power of at least 500 W and with a separate speed control can be used. The rotor should be capable of rotation in 0.6 s after starting.

2 This requirement can be verified by the use of two electrodes which are 20 mm apart and each of them is adjusted to provide an electrical contact to the tips of the rotor during the process of rotation. To a digital counter, electrodes are connected by counting elapsed time between the pulses from 2 electrodes when they are being touched at the tips of the rotor.

In between the elapsed time, comparison is made during a continuous run at a particular speed and the time elapsed is 0.6 s after start. Initially, the rotor is manually rotated to an appropriate position such that the tip of the rotor reaches the second electrode after 0.6 s. Also, the electrode can be used for calibration of a particular speed of rotation, for example, by calculating the time for a single revolution. In such case, use of a single electrode is needed.

E-3.8 Digital Timer with Relay Output Capable of

a) A setting of predetermined time in [(0 to 10) ± 0.1]s range;

b) Start when hinge arm is lifted by the piece under test; and

c) Stopping the rotor automatically when the electric point of contact is made in between the abrasive strip or the rotor and the leading wire.

E-3.9 Conditioning Chamber

It capable of maintaining the highest temperature within ± 2 °C claimed by the manufacturer.

E-4 TEST PIECES

Select 10 lengths of leading wire, each at least 0.7 m long, from 10 detonators having the same leading wire construction, composition and dimensions. The test pieces can be selected from detonators, from which the pieces are cut, or from wires of the same specification supplied by the manufacturer of the detonator.

E-5 PROCEDURE

E-5.1 Condition the test pieces inside the conditioning chamber at the highest temperature claimed by the manufacturer for at least 2 h before testing.

E-5.2 Attach each test piece to the attachment points as shown in Fig. 6, for example, by suitable clamping at the attachment points. If the detonator has twin wires they shall not be separated and shall be parallel and flat at the start of testing.

E-5.3 Position the rotor as shown in Fig. 6 which shows the starting position.

E-5.4 Lift up the hinged arm (72 ± 2) mm above the centre of the rotor and fix it in that position using a retaining pin or similar arrangement.

E-5.5 Adjust the tensile load to 8.1 N.

E-5.6 Load the hinged arm with (4.00 ± 0.02) N for category 1, or (12.20 ± 0.02) N for category 2 (excluding the adjusted load due to the hinged arm itself), depending on the category claimed by the manufacturer.

E-5.7 Carry out the test at the upper temperature limit stated by the manufacturer ± 2 ºC.

E-5.8 Start the motor.

E-5.9 The timing mechanism shall be started automatically as the hinged arm is lifted by the test piece.

E-5.10 Remove the retaining pin.

E-5.11 The rotor shall be stopped automatically when penetration through the insulation occurs (detected by electrical contact being made between the leading wire conductor and the abrasive strip or the rotor).

E-5.12 Record the time taken from the start of the test until failure, for example, penetration of the insulation.

NOTE — After each test the abrasive strip should be cleaned: for example, by using a brush with plastic bristles. The abrasive strip can be used for several tests but should be changed at suitable intervals based on practical experience of the degradation of the strip. The degradation of the strip can be monitored during routine testing by periodically testing a new set of ten category II leading wires known to give a mean time at failure of approximately 5 s with a new abrasive strip. Then it should be ensured that the mean time at failure for each subsequent set of these wires has not increased by more than 5 percent of the mean time at failure for the original set of wires (used with the new abrasive strip).

E-6 TEST REPORT

It shall clearly indicate the following information:

a) The mean and minimum elapsed time at failure.

ANNEX F

RESISTANCE OF LEADING WIRES TO CUTTING DAMAGE

(*Clause* 6.3.5)

F-1 GENERAL

During usage on site, the insulation on the leading wires of electronic detonators can be subjected to cutting forces when drawn over a sharp edge. The sharp edge cuts directly into the material. This method determines the ability of leading wire insulation to resist the cutting forces likely to be experienced in normal use.

F-2 APPARATUS

F-2.1 It comprises of following components as shown in Fig. 9.

F-2.1.1 *Pulley* A — (with a diameter of 43.0 ± 0.5) mm.

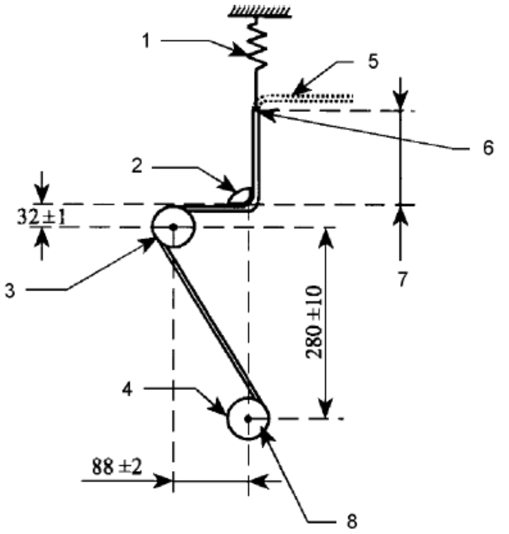
F-2.1.2 *Pulley* B — (with a diameter of 33.0 ± 0.5) mm.

F-2.1.3 *Tungsten Carbide Edge* — that have a cutting edge of 90° radiused to (0.07 ± 0.02) mm.

F-2.1.4 *Electrical Device* — to detect when the point of electrical contact is made in between the cutting edge and the conductor in the leading wire.

F-2.1.5 *Electric Motor* — having a gearbox which is capable of rotating pulley B at $0.125_0^{+0.008}$ r/s and its final position is also maintained when the power is switched off to the motor.

F-2.1.6 *Spring Balance* — or any kind of alternative arrangement which is capable of applying a gradual increasing force by indicating its value.

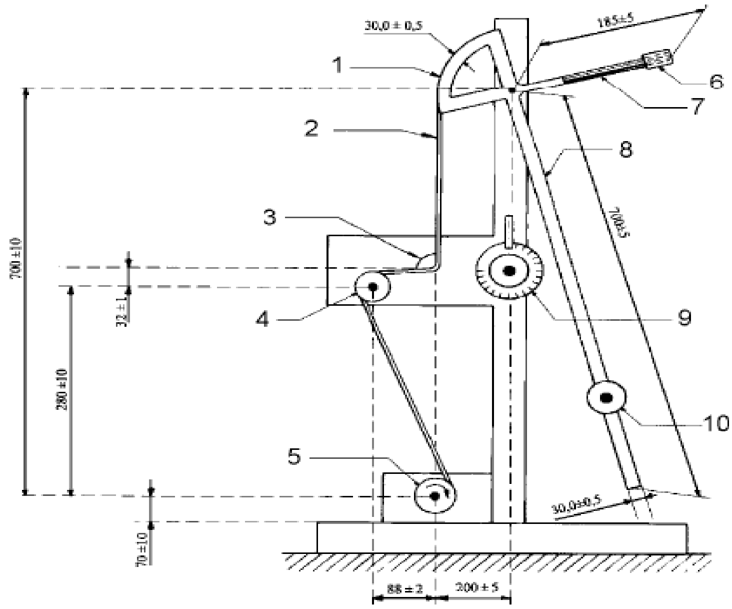


Key

1	Spring balance	5	Remaining leading wire
2	Tungsten carbide edge	6	Suitable attachment to the leading wire
3	Pulley A	7	(375 ± 20) mm at start of the test
4	Pulley B	8	Suitable attachment to the leading wire

FIG. 9 PRINCIPLE OF TEST APPARATUS

Fig. 10 illustrates an example of an apparatus having an equivalent alternative arrangement for recording and applying the maximum value of applied force.



Key

1	Internal radius 200 mm	7	Diameter (12 ± 0.2) mm
2	Leading wire	8	Arm of a lever on steel with thickness of (8.5±0.2) mm
3	Tungsten carbide edge	9	Protractor
4	Pulley A	10	Movable load
5	Pulley B		
6	Movable balance weight of (860 ± 10)g		

FIG. 10 EXAMPLE OF A TEST APPARATUS

F-2.2 Conditioning Chamber — capable of maintaining the highest temperature within ± 2 °C claimed by the manufacturer.

F-3 TEST PIECES

Select 20 lengths of leading wire, each (3.0 ± 0.5) m long, from 20 detonators of a specific type having the same leading wire type, composition and dimensions. The test pieces can be selected from detonators, from which the pieces are cut, or from wires supplied by the manufacturer of the detonator. If the detonator has twin wires they shall not be separated and shall be parallel and flat at testing.

F-4 PROCEDURE

F-4.1 Condition the test pieces in the conditioning chamber at the highest temperature claimed by the manufacturer within ± 2 °C for at least 2 h prior to testing.

F-4.2 For each of the 20 test pieces attach one end of the leading wire to the spring balance and the other end to pulley B (driven by the motor) so that it passes over the tungsten carbide cutting edge and pulley A, as shown in Fig. 9.

F-4.3 Carry out the test at the highest temperature claimed by the manufacturer within ± 2 ºC.

F-4.4 Start the electric motor to draw the wire over the cutting edge and apply the gradually increasing load.

F-4.5 When the spring balance or similar arrangement reads (7.0 ± 0.5) N stop the apparatus and remove the leading wires.

F-4.6 Record whether there has been an electrical contact between the leading wire conductor and the tungsten carbide cutting edge.

F-5 TEST REPORT

It shall clearly indicate the following information:

a) The test temperature; and

b) The number of wires which had electrical contact before the test was completed.

ANNEX G

RESISTANCE TO CRACKING IN LOW TEMPERATURES OF LEADING WIRES

(*Clause* 6.3.6)

G-1 GENERAL

During usage on site, leading wires of electronic detonators can experience conditions which can produce cracking of the insulation, for instance when kinks or loops on insulated leading wires are subjected to a sudden traction under cold conditions. Plastics materials generally become more brittle as temperature decreases. This method deals with the ability of leading wire insulation to resist the conditions likely to be experienced in normal use.

G-2 APPARATUS

G-2.1 Temperature-Controlled Chamber — capable of maintaining a specified temperature to ± 2 ºC, deep enough to allow the wire to be fully extended.

G-2.2 Rigid Frame — for fixing the wires.

G-2.3 Mass — of (500 ± 10) g.

G-2.4 Release System — for the weight (for example, electro—magnetically operated).

G-3 TEST PIECES

Select 20 pieces of wire, length (500 ± 50) mm, of each type, composition and dimension of leading wire. The test pieces can be selected from detonators, from which the pieces are cut, or from wires supplied by the manufacturer.

G-4 PROCEDURE

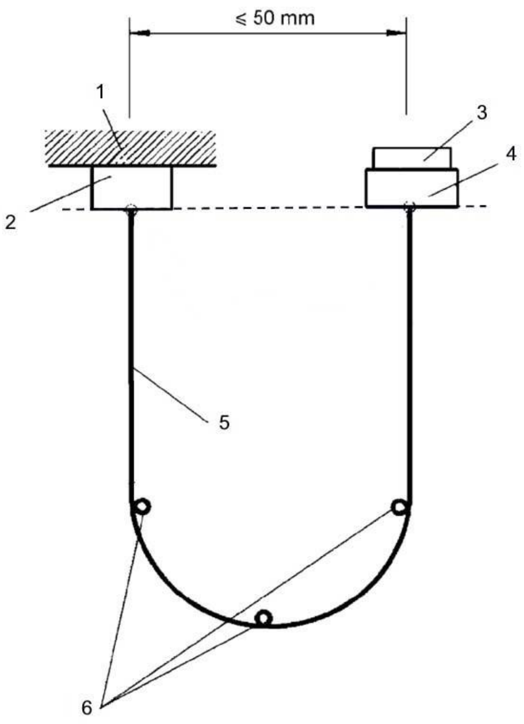
G-4.1 Mark a length of (300 ± 10) mm on the test piece about 100 mm from the ends of the test piece. Make three kinks in the test piece, each with an inner diameter between one and two times the outer diameter of the insulated wire: one in the middle of the marked length (150 + 10) mm from the marked points and the others 50 mm to 60 mm from the kink in the middle of the test piece, as shown in Fig. 11 and Fig. 12. If the detonator leading wires are the twin extruded type, both wires shall be tested together.

G-4.2 Make a 300 mm loop by fixing one marked end of the test piece to the frame and the other end to the weight.

G-4.3 Condition the test pieces for and least 1 h at a temperature not greater than the lowest temperature claimed by the manufacturer. Maintain this temperature within + 2 ºC for the duration of the test.

G-4.4 Release the weight and allow it to fall freely.

G-4.5 Determine whether any through cracking of the insulation has occurred by visual examination.



Key

1 Frame

2 Attachment to frame

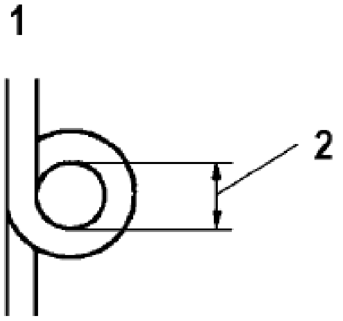
3 Release system

4 Weight

5 Leading wire

6 Kinks

FIG. 11 SCHEMATIC DIAGRAM OF TESTING ARRANGEMENT



Key

1 Leading wire

2 Inner diameter of the kink

FIG. 12 DETAIL OF A KINK

ANNEX H

MECHANICAL STRENGTH OF LEAD — WIRES, CONNECTIONS, CRIMPS AND CLOSURES

(*Clause* 6.3.7)

H-1 GENERAL

During normal use on site, the crimps/closures of detonators and their leading wires can be subjected to pulling forces. Such forces can cause a pullout of internal components of the detonator.

A pullout would either cause the detonator to explode, or would render it incapable of functioning.

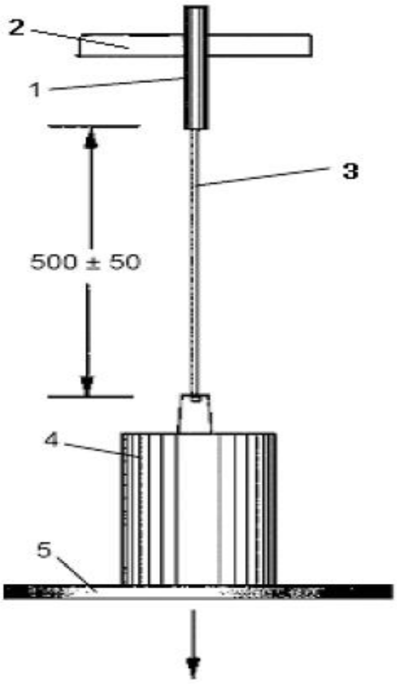
H-2 APPARATUS

The apparatus consists of the following parts as given in Fig. 13:

H-2.1 Fixing Point for the Detonator

H-2.2 Moveable Support Table

H-2.3 Weight(s) — to be attached to the leading wires, capable for applying forces of 40 N or 100 N.



Key

1 Detonator
2 Fixing point for detonator
3 Leading wires
4 Weight(s)
5 Moveable support table

FIG. 13 TEST APPARATUS

H-3 TEST PIECES

Select 40 assemblies of each specific type, whose dimensions, shell material, leading wires, construction and crimp/closure are of the same design, but primary charge/base charge, and fuse heads may vary.

H-4 PROCEDURE

The test is to be carried out at the ambient temperature.

H-4.1 Sudden Release Test

H-4.1.1 Test 20 assemblies. Attach the detonator shell to the fixing point and attach the leading wires to weights of total mass corresponding to a force of (40 ± 0.1) N. Let the weights rest on the supporting table, in such a manner that a slight tension, of about 5 N, is applied and so that the distance between the detonator and the attachment to the weights is (500 ± 50) mm.

H-4.1.2 Ensure that the leading wires are attached to the weights in such a manner that the force will be evenly distributed between them. Release the weights so that the full load is applied instantly and maintain the load for (120 ± 5) s.

H-4.1.3 Record whether or not the detonator fires during the test.

H-4.1.4 Record whether or not the leading wires break and/or whether a pullout has occurred.

H-4.2 Slow Release Test

H-4.2.1 Test 20 assemblies. Attach the detonator shell to the fixing point and attach the leading wires to weights of total mass corresponding to a force of (100 ± 1) N. Let the weights rest on the supporting table, in such a manner that a slight tension of about 5 N is applied, and so that the distance between the detonator and the attachment to the weights is (500 ± 50) mm.

H-4.2.2 Ensure that the leading wires are attached to the weights in such a manner that the force will be evenly distributed between them. Release the weights slowly until the full load is applied and maintain that load for 10 s.

H-4.2.3 Record whether or not the detonator fires during the test.

H-4.2.4 Record whether or not the leading wires break or whether a pullout has occurred.

H-4.3 Functioning Test after Sudden Release Test

H-4.3.1 After tests carried out as specified in **H-4.1**, fire each remaining detonator of which the leading wires are intact and no pullout has occurred, in accordance with the manufacturer’s instructions.

H-4.3.2 Record whether the detonators fire or not.

H-5 TEST REPORT

It shall clearly indicate the following information:

a) The temperature at which the tests are carried out;

b) Any detonation recorded in the sudden release test or the slow release test;

c) Number of detonators where leading wires break and/or a pullout occurs in the sudden release test;

d) Number of wires that break and/or number of pullouts in the slow release test; and

e) Number of detonators that do not fire in the functioning test.

ANNEX J

RESISTANCE OF DETONATORS TO BENDING

(*Clause* 6.3.8)

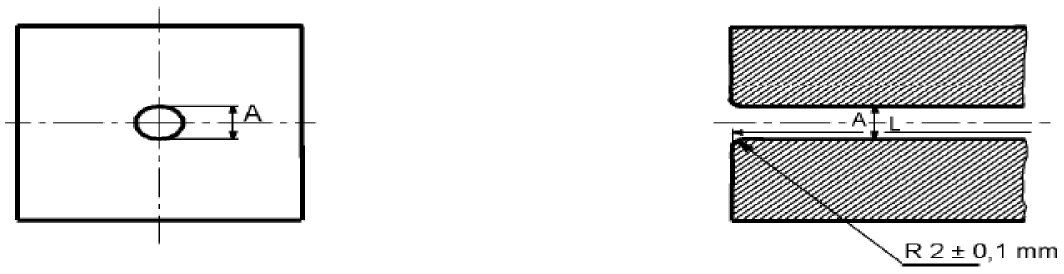
J-1 GENERAL

During use on site, detonators shells can be subjected to bending during the loading of boreholes. This test determines the ability of detonator shell to resist the bending forces likely to be experienced in normal use.

J-2 APPARATUS

J-2.1 Weights — that have the capability of applying a force of (50 ± 0.1) N with a wire attachment.

J-2.2 Steel Block — as given in Fig. 14, has a hole (A) of at least 30 mm in length. The hole diameter should not exceed the detonator diameter by higher than 0.1 mm. The radius of the hole edge shall be (2 ± 0.1) mm.

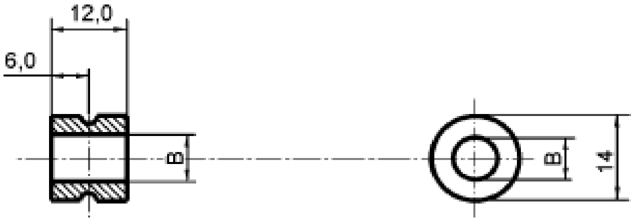


Key

A	the diameter of the hole
L	the length of the hole, minimum 30 mm

FIG. 14 STEEL BLOCK

J-2.3 Steel Rings — They are tightly fitted to each end of the detonator. Illustration has been given in Fig. 15.

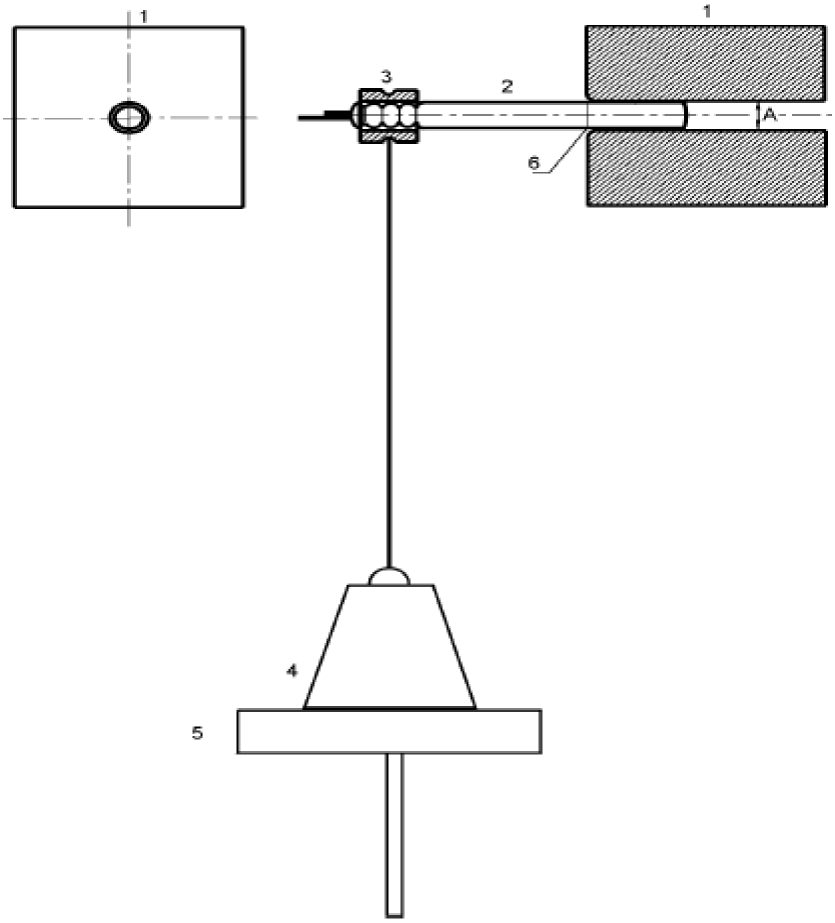


Key

B the inner diameter of the ring, tightly fitting each end of the detonator

FIG. 15 RING

J-2.4 Removable Support Table — that is capable of supporting the weights. The illustration has been given in Fig. 16.



Key

1 Steel Block
2 Detonator (shown as an electric detonator)
3 Ring
4 Weight
5 Support table
6 Approx. position of the end of the base charge
7 Diameter of the hole

FIG. 16 ASSEMBLY WITH DETONATOR SUPPORTED AT THE BASE

J-3 TEST PIECES

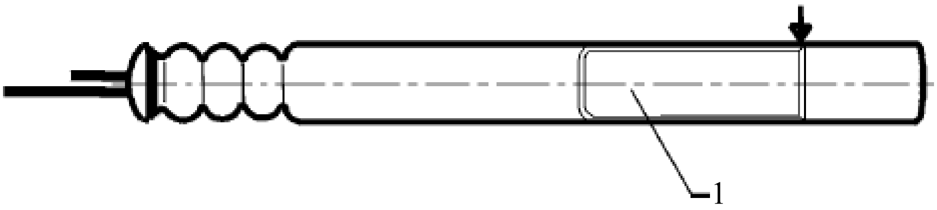
Select 13 detonators having a longest shell form a particular type with the similar compositions and design.

J-4 PROCEDURE

J-4.1 General

Determine the weakest point of the detonator as shown in the Fig. 17.

NOTE — It is the point from where the outer shell will break when subject to a 90 degree angle pulling force.



Key

1 Primary charge cap

↓ The weakest point

FIG. 17 PRINCIPLE OF FINDING WEAKEST POINTS OF THE DETONATOR

J-4.2 Detonators Supported at the Base

J-4.2.1 Test 13 detonators. Mark the weakest point at the base (*see* Fig. 17). Insert the detonator, base first, into the steel block to the weakest point. Rest the weight on the support table so that no force is applied to the detonator.

J-4.2.2 Attach the wire and ring to the end of the protruding part of detonator, as shown in Fig. 16. Slowly lower the support table so that a downward force is applied. Continue to lower the table until the detonator is fully supporting the weight. Maintain the load for at least 5 s.

J-4.2.3 Record any initiation of the detonator or cracking or breaking of the shell.

J-5 TEST REPORT

It shall clearly indicate the following information:

a) Number of initiations;
b) Number of detonators showing cracks in the shell; and
c) Length of the detonators inserted into the steel block in each test.

ANNEX K

RESISTANCE TO ELECTROSTATIC DISCHARGE

(*Clause* 6.3.9)

K-1 INTRODUCTION

This test assesses the immunity of electronic detonators with wire leads when subjected to electrostatic discharge (ESD).

K-2 PRINCIPLE

A capacitor is repeatedly charged to the appropriate test voltage and discharged across wires and between lead wires and the detonator shell.

K-3 TEST PIECES

Select 50 detonators of the same type and from the same manufacturer. The lead wire length shall not exceed 3.5 m. Stabilize all devices for test at an ambient temperature of between 15 °C and 28 °C for at least 1 h before testing.

K-4 TEST CONDITIONS

K-4.1 Carry out the test at ambient temperature and at a relative humidity not greater than 60 percent.

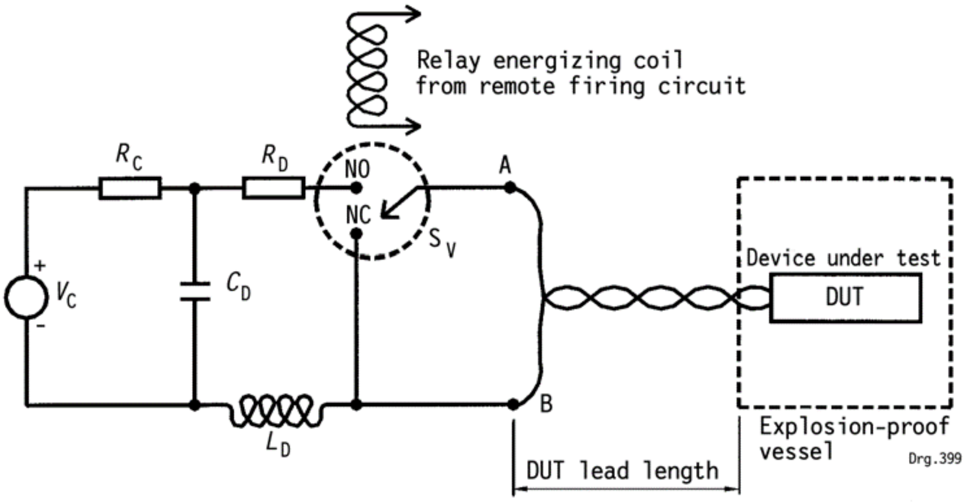
K-4.2 The lead wires shall be coiled as produced by the manufacturer.

K-5 APPARATUS AND TEST LEVEL

K-5.1 Electrostatic discharge generator (*see* Fig. 18) shall be able to charge the discharge capacitor up to the test voltage required and discharge the capacitor into the device under test through a high voltage relay.

K-5.2 The test circuit parameters and test level are as follows:

a) A capacitor of 2 500 pF ± 10 percent, with a rated voltage of 30 kV; and
b) A voltage of 30 kV ± 5 percent.



Key

C_D, Discharge capacitor 2 500 pF ± 10 percent, 30 kV. The value of the discharge voltage is measured across this capacitor;

L_D, Total inductance of the test circuit (excluding the DUT and lead wires) shall not be more than 5 µH;

R_C, Charge resistor of sufficiently high value not to contribute significantly to the discharge impulse current;

R_D, Discharge resistance of test circuit shall be minimum;

S_V, Test switch, a remotely operated high voltage relay, rated at least 30 kV; and

V_C, Supply voltage.

FIG. 18 SCHEMATIC REPRESENTATION OF THE APPARATUS FOR THE ELECTROSTATIC DISCHARGE IMMUNITY TEST ON ELECTRONIC DETONATORS

K-6 TEST CONFIGURATIONS

K-6.1 Pins-to-Case Configuration

The shell of the detonator is connected to the negative terminal of the source, and the shorted leading wires are connected to the positive terminal of ESD generator. The test impulse is applied five times to each device under test, with an interval of at least 10 s between impulses.

K-6.2 Pin-to-Pin Configuration

The shell of the detonator is left isolated in the test chamber, and ESD impulse is applied between the leading wires. The test impulse is applied five times to each device under test, with an interval of at least 10 s between impulses.

K-7 PROCEDURE

K-7.1 Following the operating instructions for the test apparatus, discharge the capacitor as indicated in **K-6.1** into the 25 electronic detonators.

K-7.2 Record whether there was an ignition.

K-7.3 Repeat the test for remaining 25 electronic detonators as indicated in **K-6.2**.

K-7.4 In the event of an ignition, stop testing and record the electronic detonator as having failed.

K-8 TEST REPORT

The test report shall have the following information:

a) Whether there was any detonation.

ANNEX L

DETERMINATION OF FLASH OVER VOLTAGE

(*Clause* 6.3.10)

L-1 GENERAL

Detonators can also be subjected to the application of high voltages caused by electrostatic charging of the firing circuit. To determine the ability of detonators to withstand these applied high voltages without initiating prematurely, it is essential to determine the value of applied D.C. voltage which causes flash-over between the detonator leading wires and the detonator shell.

L-2 TEST PIECES

Select 30 detonators of each specific type, having the same design and chemical composition of fuse head, primary charge, and secondary charge. If the detonators form part of a series with different delay times, select 30 detonators with delay times as evenly distributed throughout the series as possible.

L-3 APPARATUS

L-3.1 A High Voltage Source — capable of applying a d.c. voltage of up to 10 kV with an accuracy of ± 50 V and not more than 3.0 percentage distortion. The voltage shall be continuously adjustable. The current output of this voltage source shall be limited to a maximum of 5 mA to prevent the buildup of an electric arc.

L-3.2 An Ammeter — to detect a voltage flash-over.

L-4 PROCEDURE

L-4.1 Connect the detonator shell to one terminal of the voltage source. Short circuit both leading wires of the detonator and connect them to the second terminal. Increase the voltage continuously at a rate between 50 V/s and 200 V/s until a flash-over is detected by a sudden increase in the circuit current. Record the voltage at which the flash-over occurs.

L-4.2 Repeat the procedure described in **L-4.1** for each of the remaining detonators. Calculate the mean value and the standard deviation of the flash-over voltage. Calculate the sum of the mean value and 2.33 times the standard deviation (upper value).

L-5 TEST REPORT

It shall clearly indicate the following information:

a) The mean value of the flash-over voltage, the standard deviation, and the upper value; and
b) Number of detonators initiated by the flash-over.

ANNEX M

DETERMINATION OF CAPACITANCE, INSULATION RESISTANCE, AND INSULATION BREAKDOWN OF LEAD WIRES

(*Clause* 6.3.11)

M-1 GENERAL

Detonators can also be subjected to high voltages caused by electrostatic charging of the firing circuit during loading. To assess the ability of detonators and their leading wires to withstand these voltages, without premature initiation, it is essential;

a) To determine the capacitance of the leading wires to ensure that they cannot be charged to a dangerous level;
b) To determine the insulation resistance of the leading wires; and
c) To check that there is no breakdown of the leading wire insulation when subjected to high voltage.

M-2 REAGENT

M-2.1 Conductive Solution — consisting of water, and 3 percent sodium chloride with a purity greater than 99 percent.

M-3 APPARATUS

M-3.1 Meter for Measuring Capacitance — accurate to 1.0 percent.

M-3.2 Beaker — of suitable size and in a non–conductive material.

M-3.3 A Copper Electrode

M-3.4 Temperature–Controlled Chamber — capable of maintaining a temperature of (20 ± 2) °C for 24 h and (40 ± 2) °C for 2 h or higher if claimed by the manufacturer.

M-3.5 A High Voltage Generator — capable of maintaining (5 000 ± 50) V between the twisted ends of the leading wire conductor and the electrode.

M-3.6 Voltmeter — capable of measuring in the range of 0 kV to 5 kV and accurate to 1.5 percent.

M-3.7 Meter — capable of measuring insulation resistance up to 100 MΩ, accurate to 1.0 percent, and capable of giving a voltage of (500 ± 10) V.

M-4 TEST PIECES

Select 25 lengths of leading wire, each at least 1.5 m long, from 25 detonators of a specific type having the same dimensions, leading wire insulation and conductor material.

M-5 PROCEDURE

M-5.1 Determination of Capacitance

Mark a length of (1 ± 0.05) m on the insulation of each leading wire sample. Cut the wire a few decimeters longer than the marked length. Fold the wire in the middle taking care not to make a sharp kink in the insulation at the mid–point. Strip approximately three centimeters of insulation from each end of the wire and twist the two bare ends of the conductor together. Wind the folded wire into a loose cylindrical spiral and place it inside the beaker so that the twisted bare ends of the conductor are at the top of the beaker. Attach the twisted bare ends to the top of the beaker with adhesive tape, so that they protrude out of the beaker. Place the copper electrode in the beaker and fill the beaker with the conductive solution so that the whole wire spiral is submerged up to the 1 m marks on the insulation of the wire, making sure that the twisted bare ends are above the liquid surface. Store the wire in the solution for a period of at least 24 h, in the temperature-controlled chamber maintained at (27 ± 2) °C. Remove the beaker from the chamber. Connect the capacitance meter between the twisted bare conductor ends and the copper electrode. Record the capacitance in pico-Farads (pF).

M-5.2 Determination of Resistance to High Voltage

Without removing the wire spiral from the beaker of conductive solution, connect the high voltage generator between the twisted bare ends of the conductor and the copper electrode. Apply a voltage of (5 000 ± 50) V and maintain it for 60 s. The leakage current shall not be greater than 0.1 mA. Record whether or not the insulation breaks down during the test, as demonstrated by a sudden drop in the applied voltage.

M-5.3 Determination of Insulation Resistance

Without removing the wire spiral from the beaker of conductive solution, store it for a period of 2 h in the temperature–controlled chamber maintained at (40 ± 2) °C or higher if claimed by the manufacturer. Connect the meter between the twisted bare ends of the conductor and the copper electrode. Apply a voltage of (500 ± 10) V for 60 s. Record the insulation resistance in MΩ.

M-5.4 Calculation of Results

Calculate the mean value of the capacitance, *C*, the standard deviation, *s*, and the value of ($C + 2.33 \times s$).

M-6 TEST REPORT

It shall clearly indicate the following information:

a) Capacitance as mean value plus 2.33 times the standard deviation;
b) Resistance to high voltage as the number of breakdown(s); and
c) Insulation resistance as the lowest measured value.

ANNEX N

SYSTEM FUNCTION TEST

(*Clause* 6.3.12)

N-1 INTRODUCTION

The purpose of this test is to determine the proper operation of the two way communication between the detonators and the firing unit and ignition of the detonators connected to the firing device with the specified wire length of the firing line and with the maximum number of detonators per blast as defined by manufacturer.

N-2 TEST PIECES

One original ignition device and maximum volume of detonators defined by the manufacturer.

N-3 APPARATUS

Original firing unit charged up, firing line or firing line impedance load specified by the manufacturer and the number of detonators described above.

N-4 PROCEDURE

Use a firing device with enough charge, the quantity of detonators as described above, connected to the firing device with the firing line as described above. The detonators must relate to the specified tools by the manufacturer. Fire the longest delay time specified by manufacturer. Make sure, that the detonators before every firing test are in the reset state and respond back to the firing unit with their identification number proving their connectivity and preparedness to fire, like the start condition before a real blast.

N-5 TEST REPORT

The test report shall have the following information:

a) Whether any detonator misfired during testing;

b) Whether there was any loss of function or loss of two way communication;

c) The number of detonators connected in the single blast;

d) The length of the trunk line cable used between the detonator and the firing unit; and

e) The results of the examinations and tests obtained.

ANNEX P

ELECTROMAGNETIC COMPATIBILITY AND INTERFERENCE TESTING

(*Clause* 6.3.13)

P-1 INTRODUCTION

The purpose of this test is to verify that electronic initiation systems is safe and reliable when subjected to electromagnetic radiation.

P-2 TEST PIECES

For the tests described below, 10 dummy detonators shall be used with all type of equipment from the electronic initiation system. When performing tests the equipment shall be connected and in operation during the respective tests with the dummy detonators. All type of equipment in electronic initiation system shall be tested.

P-3 APPARATUS

As specified in the referred documents.

P-4 PROCEDURE

P-4.1 For each test below, record any loss of function or any unintended initiation of dummy detonators.

P-4.2 In case of blast equipment, record the proper firing of all dummy detonators after giving the firing command.

P-5 ELECTROSTATIC DISCHARGE IMMUNITY TEST

Perform the electrostatic discharge immunity test in accordance with IS 14700 (Part 4/Sec 4) (identical adoption of IEC 61000-4-4) with a voltage corresponding to Level 4:

a) Air discharge: 15 kV; and

b) Contact discharge: 8 kV.

P-6 SAFETY AGAINST UNINTENDED INITIATION

P-6.1 For the tests described below, apply the worst–case condition (or conditions) for the specific system as close to the real field conditions as possible.

P-6.2 Also consider the worst-condition regarding choice of wire length and possible connection of detonators to earth.

P-6.3 For each test below record any unintended initiation of the dummy detonators:

a) Perform immunity to conducted disturbances, induced by radio-frequency fields test in accordance with IS 14700 (Part 4/Sec 6) (identical adoption of IEC 61000-4-6) with a voltage of 30 V at frequencies from 150 kHz – 80 MHz;

b) Perform radiated, radio–frequency, electromagnetic field immunity test in accordance with IS 14700 (Part 4/Sec 3) (identical adoption of IEC 61000-4-3) with a field strength of 30 V/m at frequencies from 80 MHz – 1 GHz; and

c) Perform radiated, radio–frequency, electromagnetic field immunity test in accordance with IS 14700 (Part 4/Sec 3) (identical adoption of IEC 61000-4-3) with a field strength of 10 V/m at frequencies from 1 GHz – 2 GHz.

P-7 FUNCTIONING DURING STRESS

P-7.1 For the tests described below apply the worst–case condition for the specific system as close to the real field conditions as possible regarding choice of wire length and possible connection of detonators to earth.

For each test record any loss of function or unintended initiation.

a) Perform immunity to conducted disturbances, induced by radio–frequency fields test in accordance with IS 14700 (Part 4/Sec 6) (identical adoption of IEC 61000-4-6) with a voltage of 10 V at frequencies from 150 kHz — 80 MHz. Select 30 discrete frequencies evenly distributed in the frequency range each for which a complete initiation process including firing is carried out.

Additionally perform firing after completion of the test (that is, without stress applied).

a) Perform radiated, radio-frequency, electromagnetic field immunity test in accordance with IS 14700 (Part 4/Sec 3) (identical adoption of IEC 61000-4-3) with a field strength of 10 V/m at frequencies from 80 MHz – 1 GHz. Select 10 discrete frequencies evenly distributed in the frequency range each for which a complete initiation process including firing is carried out. Additionally perform firing after completion of the test (that is, without stress applied); and

b) Perform radiated, radio—frequency, electromagnetic field immunity test in accordance with IS 14700 (Part 4/Sec 3) (identical adoption of IEC 61000-4-3) with a field strength of 3 V/m at frequencies from 1 GHz – 2 GHz. Select 10 discrete frequencies evenly distributed in the frequency range each for which a complete initiation process including firing is carried out. Additionally perform firing after completion of the test (that is, without stress applied).

P-8 RADIO FREQUENCY EMISSION TEST

Perform the radio frequency emission test in accordance with CISPR 11, Class A (industrial environmental).

NOTE — The result of the test to be declared by the manufacturer based on any authorized laboratory.

P-9 TEST REPORT

The test reports shall have following information:

a) The results of the examinations and tests obtained;

b) Whether or not the equipment was able to meet all the requirements; and

c) Whether there was any loss of operation or unintended initiation.

NOTE — The results of the tests in this section can be declared by the manufacturer based on testing at any authorized laboratory.

ANNEX Q

ABORT FUNCTION TEST

(*Clause* 6.3.14)

Q-1 INTRODUCTION

Q-1.1 The Electronic Initiation systems, conducts series of sequences before the detonators are ever blasted. Where in there can be scenarios, which requires these blast sequences to be aborted in between. Thus, every system must have a built-in safe abort mechanism.

Q-1.2 The sample electronic detonator shall be charged up to the full voltage required to detonate it and shall not detonate in the absence electronic signature signal/stimuli. The stored energy in the detonator could be discharged if required by external means and after discharging the electronic signature applied to it shall not detonate the electronic detonator.

Q-1.3 The manufacturer shall also declare the time required (after aborting and bus line disconnection) when the detonators can be considered safe.

Q-2 PROCEDURE

Below test shall be conducted with at least 10 detonator samples connected with the blaster.

NOTE — If the blaster has maximum capacity of less than 10 detonators then actual no of detonators shall be connected.

1 Connect 10 detonators with the blaster.
2 Start blast sequence and bring the samples to charged or armed state, where they can initiate on receiving the firing signal.
3 Wait for 1 min to ensure that the detonators will not explode in absence of the firing command.
4 Press ‘Abort’/‘Cancel’/‘Discharge’ button or switch after which the detonator should disarm/discharge in time specified by the manufacturer and shall be revert to a safer state.
5 After a suitable time specified by the manufacturer, if the blaster has the dedicated firing button then press ‘Fire’ button. If there is no dedicated ‘Fire’ button then this step is not applicable.

Q-3 TEST REPORT

The test report shall have following information:

a) Whether there were any initiations; and

b) The results of the examinations and tests obtained.

ANNEX R

(*Foreword*)

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